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THE GERMINATION OF WEED SEEDS AS INFLUENCED BY ENVIRONMENTAL FACTORS

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By

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ABSTRACT

The problem involved in this investigation was that of determining the effect of environmental factors upon the germination of twelve species of weed seeds.

The seeds were harvested, divided into three groups designated as Groups I, II and III, and stored under different environmental conditions. Group I, a temperature control group, was stored under conditions of normal temperature, Group II under continued cold and Group III was subjected to intermittent freezing and thawing. A small fourth group, consisting of seeds of species which failed to germinate or showed low percentages of germination in earlier tests was subjected to scarification. These seeds were taken from Group I.

Plantings of seeds of Groups I, II and III were made monthly from September to June, exclusive of December, in specially prepared sterile soil. Irregular plantings of Group IV were made in April, May, and June.

Upon germinating it was found that the per cent of combined germinations of all seeds in Groups I, II, and III was 6.7, 9.7, and 11.5 per cent, respectively. Indications were that the increased germination percentage of Groups II and III was not due to greater germinations in one or two species alone, for it was found that

75 per cent of all species had the greatest number of seeds germinating in Groups II and III. The per cent of germination in Groups I, II, and III was very low in October, immediately following harvest. The per cent of germination was greatest in Groups I, II and III during the fall and spring months. Scarification of the seed coats seemed to hasten the germination of some seeds while it had but little effect on others.

INTRODUCTION

Various investigations pertaining to the germination, viability, dormancy and rest periods of seeds have been made. Seed testing has become an important work of state and federal agricultural experimental stations. Numerous studies have been made concerning the effect of storage upon seeds of various plants such as ornamentals, vegetables, conifers, cereals and aquatic plants. Crocker (1938), gives an extensive review of the literature pertaining to longevity and germination of seeds, changes involved in the degeneration of seeds with age, and the effect of storage conditions upon their rate of degeneration. He cites many records of the life-span of seeds of wild plants in herbaria and seed cupboards, seeds of cultivated plants in storage, and seeds in soil. According to Crocker, some seeds lose their vitality in a very short time if they are kept in open air after harvest. Jones (1920) observed in his study, that the seeds of the river maple, which have a water content of about 58 per cent when they fall from the tree, are killed when the moisture content reaches 30 to 34 per cent. With a high temperature this death point might be reached in six days, but he found that the seeds would retain their

full vitality for 102 days when stored in a closed vessel over water at the freezing point if the carbon dioxide accumulation was prevented. He also found that seeds of the fall fruiting sugar maple could withstand complete drying and responded best to three months low temperature stratification. Duvel (1905) found that wild rice seeds lose their vitality if they are allowed to dry in the air for even a few days, but that they retain it until spring if stored in water at freezing temperature. Seeds of the wild rice are dormant when mature, and storage in water near the freezing point after-ripens them as well as maintains their vitality. Nakajima (1925) observed that seeds of the willows lost their vitality quickly when exposed to the air, but retained it much better in closed tubes over a solution of 50 per cent by volume of sulphuric acid in water.

These numerous investigations indicate that the type or method of storage affects the germination of seeds. The purpose of this investigation was to determine the effect of conditioned storage, namely: normal temperature, continued cold, intermittent freezing and thawing, and scarification upon the germination of twelve species of weed seeds.

RELATED STUDIES

Fawcett (1908) made an extensive study upon the germination of seeds. He used fifty-two different species of weed seeds which were collected in September, October, and November, threshed and placed in paper envelopes. Fifty seeds of each sample were planted in sand each month from November until May. The effects of freezing and thawing upon seeds was obtained by placing the seeds in sacks inside a thin wooden box. The box was then buried in the ground, out of doors, with only a thin layer of the top of the box exposed. The seeds were removed in April and planted by the side of control seeds that had been indoors all winter. Fawcett found that the general effect of exposing seeds to freezing and thawing was both to increase the percentage of germination and to shorten the period of time between the planting and the first germination. He also concluded that there were two natural periods for the best germination of seeds: the fall and the spring. His entire test experiment shows a very low average per cent of germination.

Blake (1936) collected seeds of several common species of prairie plants each fall during a four year period and tested their viability and germination by planting in the soil, usually in the greenhouse. She concluded that:

(1) germination fluctuated from month to month for any single lot of seeds of these plants; (2) there was a general tendency to yield maximum germinations in the spring and in the fall; (3) germination immediately after harvest was usually very low; (4) seeds which had been exposed in a dry condition to freezing temperatures for several weeks had a somewhat higher percentage of germination than those seeds which had been kept for the same length of time at room temperatures; (5) the largest number of seedlings of a given species usually appeared in practically the same number of days from both frozen and unfrozen seeds.

MATERIALS AND METHODS

The plants used in this investigation were twelve species of common weeds collected in Butler County, Kansas, during the late summer and fall of 1940. These plants with other informational data are listed in Table I.

The nomenclature used is according to that given by Rydberg (1932). Data on life duration, habitat, flowering time, and distribution in Kansas is that as given by Gates (1932, 1940).

From Table I it is readily observed that the habitats vary from cultivated soils to prairie sod. The time of flowering and seed production and ripening also vary. Some plants, Oenothera missouriensis, flowered only in the late spring and the seed soon matured. Others, Pentstemon Digitalis, flowered in the spring and early summer but the seed did not ripen until fall. Hibiscus Trionum flowered and produced mature seeds throughout the summer and fall while Chenopodium album flowered and produced seeds only in late summer and fall.

The soil for the germination experiments was composed of one part garden soil made sterile by two separate heatings one week apart, one part sand and one part peat moss. The sterile soil and sand were sifted to produce a uniform texture and then were thoroughly mixed

TABLE I

Scientific Names, Life Durations, Habitats, Flowering Times, Distribution in Kansas, and Collection Dates of Plants Used

Plant	Life* Duration	Habitat	Flowering Time	Distri-bution	Collect. Date
Oenothera missouriensis Sims	P	Rocky prairies	May to July	East two-thirds	8-11-40
Convolvulus arvensis L.	P	Cultiva-ted-waste	May to Sept.	Through-out	9- 5-40
Physalis lobata Torr.	A	High plains	Apr.to August	West	8-23-40
Hibiscus Trionum L.	A	Wasteland Fields	Aug.to Sept.	East three-quarters	8-23-40
Amaranthus retroflexus L.	A	Wastelamd Fields	Summer Fall	Through-out	8-23-40
Abutilon Theophrasti Medic.	A	Wasteland	Aug.to October	East half	8- 1-40
Sida spinosa L.	A	Wasteland Fields	Summer	East half	9- 5-40
Helianthus annuus L.	A	Fields Roadside	June to October	Through-out	9-28-40
Pentstemon Digitalis (Sweet) Nutt.	P	Sod prairie	May and June	East Half	8-11-40
Solanum rostratum Dunal	A	Plains prairies	May to Sept.	Through-out	8-23-40
Chenopodium ambrosioides L.	A	Wasteland Thickets	Summer Fall	East half	9-28-40
Chenopodium album L.	A	Wasteland Fields	Summer Fall	Through-out	10- 1-40

* A-annual; P-perennial

with the peat moss. This soil mixture was stored in the basement and used for all germination tests.

After the seeds were gathered and threshed they were carefully checked and all those of probable low quality were discarded. One thousand seeds of each species of plant were placed in three airtight containers (bottles) and properly labeled. This made three groups composed of twelve bottles each. Group I was used as the control series and was stored in the basement where the temperature ranged from sixty to seventy degrees Fahrenheit. Group II was stored in the refrigerator at temperature of thirty-eight degrees Fahrenheit. The third group was placed in the freezing compartment of the refrigerator where the temperature was ten degrees Fahrenheit. Groups I and II were left in their respective storage places throughout the entire experiment but Group III was arbitrarily removed and replaced at intervals of one, two, three, or four weeks. At no time did Group III remain longer than four weeks either out of or in the freezing compartment.

To these three groups might be added a fourth group derived from the control seeds and consisting of scarified seeds of those species that showed low germinations or failed to germinate in earlier test plantings of Groups I, II, and III.

All germination tests were carried on in the basement. Each month from September to June, exclusive of December, seeds of each of the twelve species were planted in lots of 100 in perforated, paraffin paper baking cups. The cups were then placed in definite order in a bed of wet sand and kept as near as possible under uniform conditions. Special effort was made to record daily observations during the first days of each planting. No plantings were discarded until the last of May. The May planting was observed only eight days and the June planting fifteen days. The first planting in September consisted only of the controls since there had not been sufficient time for the refrigeration or freezing and thawing. The first control planting of Chenopodium ambrosioides was made in October. First plantings of Groups II and III of the same species were made in November.

During the experiment, twenty-five plantings were made of each of the twelve species of seeds stored in Groups I, III, and III. Nine of these plantings were from Group I and eight each from Groups II and III.

Irregular plantings were made of Group IV in April, May and June. Amaranthus retroflexus, Chenopodium album, Chenopodium ambrosioides and Convolvulus arvensis because of low germinations in earlier tests were subjected to scarification of the seed-coat for effect upon germination. Physalis lobata and Helianthus annuus having

not germinated under any conditions were subjected to scarification for the same reason. Seeds were scarified by rubbing lightly between two sheets of sandpaper. Although care was used in the scarifying process, no doubt some of the embryos in the smaller seeds were injured enough to interfere with germination.

OBSERVATIONS AND RESULTS

Observations and results obtained from nine monthly plantings of seeds were tabulated in Tables II to XI and shown graphically in Figures 1 to 10.

The term maximum germination was determined by the greatest number of germinations of a single day.

Oenothera missouriensis

A study of Table II shows that Oenothera missouriensis had a very low percentage of germination in all three groups. Four of the nine plantings, those for September, January, April and May yielded no germinations. The greatest number of germinations for a single planting was six and they were found in Group I for June. There seemed to be no best natural period for seed germination in this species. Figure 1 shows a small peak of germination in June for Group I, and one in November for Group II.

The combined germinations of all seeds in each of the three groups were as follows: Group I, 1.2 per cent; Group II, 0.625 per cent; and Group III, 0.375 per cent.

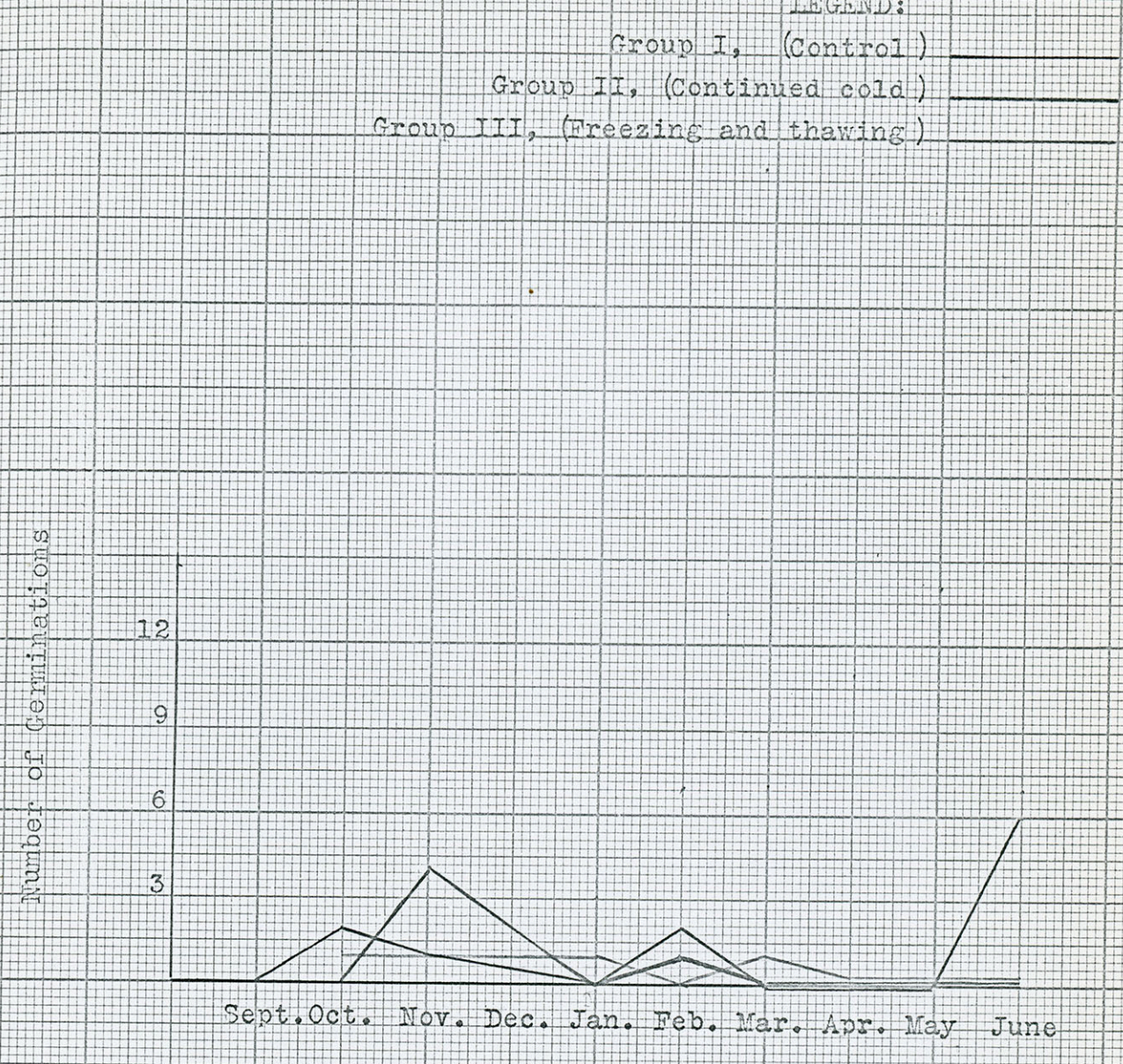


Figure 1. A Comparative Study of Germination in Nine Plantings of Oenothera missouriensis

TABLE II

Germination Data of *Oenothera missouriensis*

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept. 21	I	100	--	--	0	0
Oct. 5	I	100	13	13	2	2
	II	100	--	--	0	0
	III	100	5	5	1	1
Nov. 10	I	100	23	23	1	1
	II	100	7	θ*	4	4
	III	100	21	21	1	1
Jan. 5	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Feb. 2	I	100	97	97	2	2
	II	100	86	86	1	1
	III	100	--	--	0	0
Mar. 15	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	8	8	1	1
Apr. 13	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
May 25	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
June 8	I	100	7	7	6	6
	II	100	--	--	0	0
	III	100	--	--	0	0
Total	I	900	--	--	11	1.2
	II	800	--	--	5	.625
	III	800	--	--	3	.375

* θ - no maximum germination appeared.

Convolvulus arvensis

A study of Table III shows that Convolvulus arvensis during the nine months of observation, yielded its greatest number of germinations at definite periods. The peak of germination for Group I as shown in Figure 2 was in October, for Group II it was in May and for Group III there were two peaks, one in November and one in May.

Twelve of the nineteen maximum germinations were on the same date as the first germination. Six plantings produced no maximum germinations.

The per cent of combined germinations of all seeds in Group I was 4.9 per cent, for those in Group II it was 6.9 per cent and for those in Group III it was 9.6 per cent.

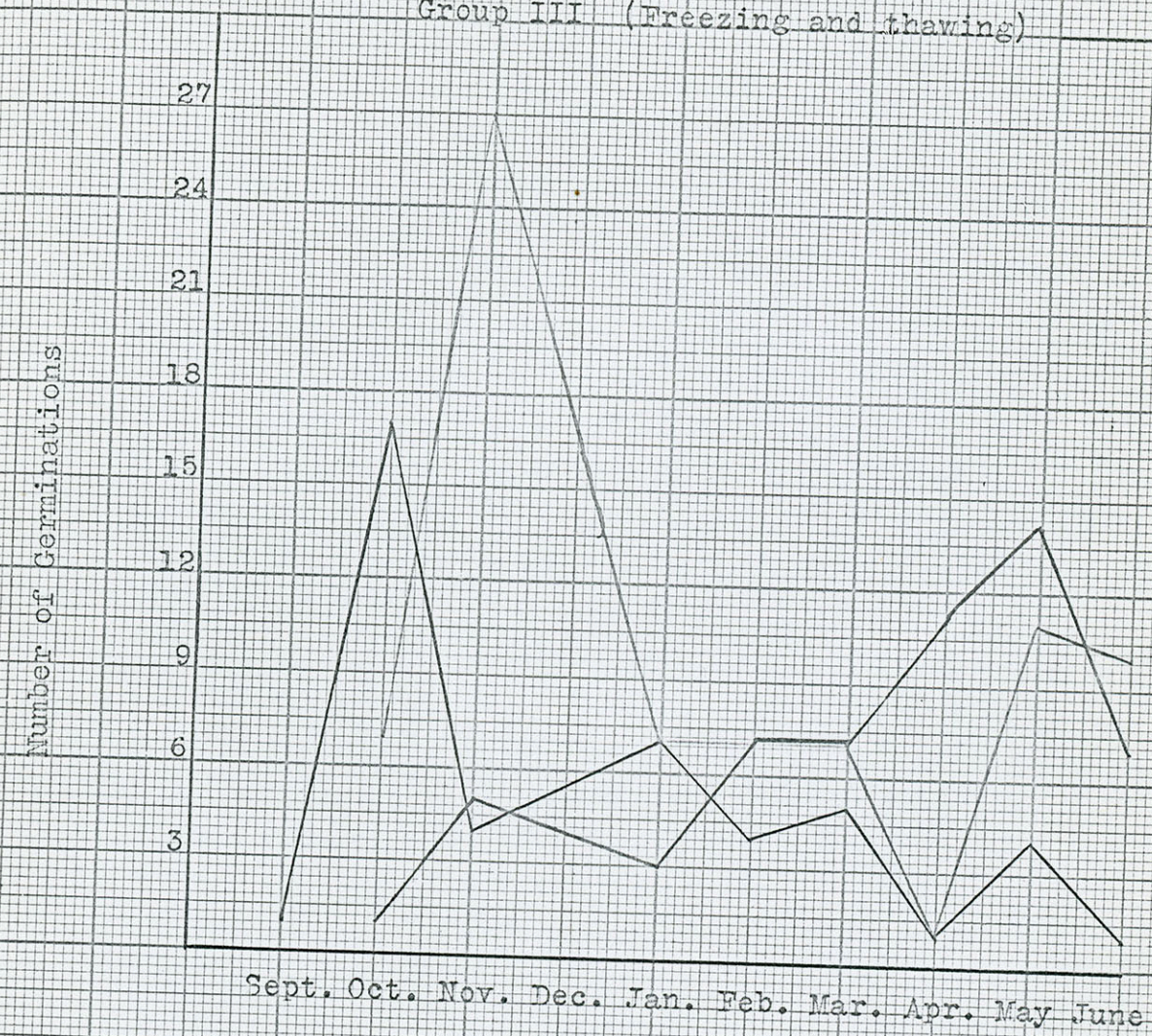


Figure 2. A Comparative Study of Germination in Nine plantings of Convolvulus arvensis

TABLE III

Germination Data of Convolvulus arvensis

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept. 21	I	100	129	129	1	1
Oct. 5	I	100	13	5	17	17
	II	100	5	5	1	1
	III	100	21	θ*	7	7
Nov. 10	I	100	8	13	4	4
	II	100	14	14	5	5
	III	100	15	69	27	27
Jan. 5	I	100	14	θ	7	7
	II	100	6	θ	3	3
	III	100	6	11	7	7
Feb. 2	I	100	15	θ	4	4
	II	100	4	8	7	7
	III	100	4	θ	7	7
Mar. 15	I	100	8	θ	5	5
	II	100	8	8	7	7
	III	100	8	8	7	7
Apr. 13	I	100	6	6	1	1
	II	100	3	3	11	11
	III	100	13	13	1	1
May 25	I	100	5	5	4	4
	II	100	5	5	14	14
	III	100	5	5	11	11
June 8	I	100	6	6	1	1
	II	100	9	9	7	7
	III	100	4	7	10	10
Total	I	900	--	--	44	4.9
	II	800	--	--	55	6.9
	III	800	--	--	77	9.6

* θ - no maximum germination present.

Hibiscus Trionum

A study of Table IV shows that Hibiscus Trionum germinated better than most seeds in this investigation. Two peaks in germination developed in each of the three groups. Those in Group I were in September and February,-March. Those of Group II were in January and May and those of Group III were in November - January and May. Figure 3 shows the same facts in graph form.

In eleven of the twenty-two cases the maximum germination took place on the date of the first germination.

The per cent of combined germination of all seeds in Group I was 26.6 per cent, for all seeds in Group II it was 29.9 per cent and for all seeds in Group III it was 36.3 per cent.

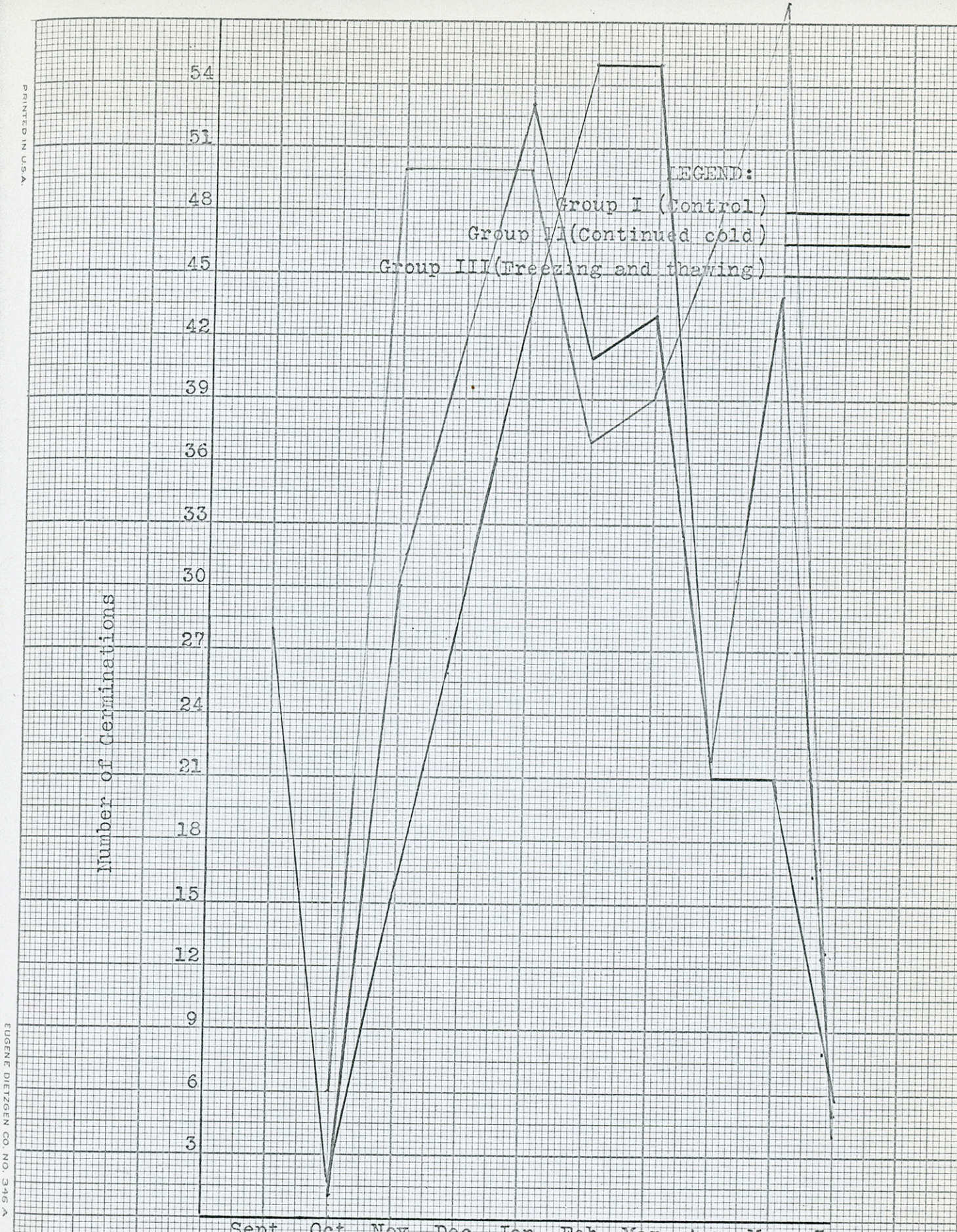


Figure 3. A Comparative Study of Germination in Nine Plantings of *Hibiscus Trionum*

TABLE IV

Germination Data of Hibiscus Trionum

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept.21	I	100	9	θ	28	28
Oct. 5	I	100	13	13	2	2
	II	100	21	21	1	1
	III	100	21	θ	6	6
Nov. 10	I	100	13	13	16	16
	II	100	14	θ	30	30
	III	100	15	15	50	50
Jan. 5	I	100	11	11	43	43
	II	100	6	11	53	53
	III	100	6	11	50	50
Feb. 2	I	100	4	8	55	55
	II	100	4	8	41	41
	III	100	4	8	37	37
Mar. 15	I	100	8	8	55	55
	II	100	8	20	43	43
	III	100	8	15	39	39
Apr. 13	I	100	6	13	21	21
	II	100	3	6	22	22
	III	100	10	10	47	47
May 25	I	100	5	7	21	21
	II	100	5	5	44	44
	III	100	5	5	58	58
June 8	I	100	6	6	6	6
	II	100	6	6	5	5
	III	100	6	7	4	4
Total	I	900	--	--	247	26.6
	II	800	--	--	239	29.9
	III	800	--	--	291	36.3

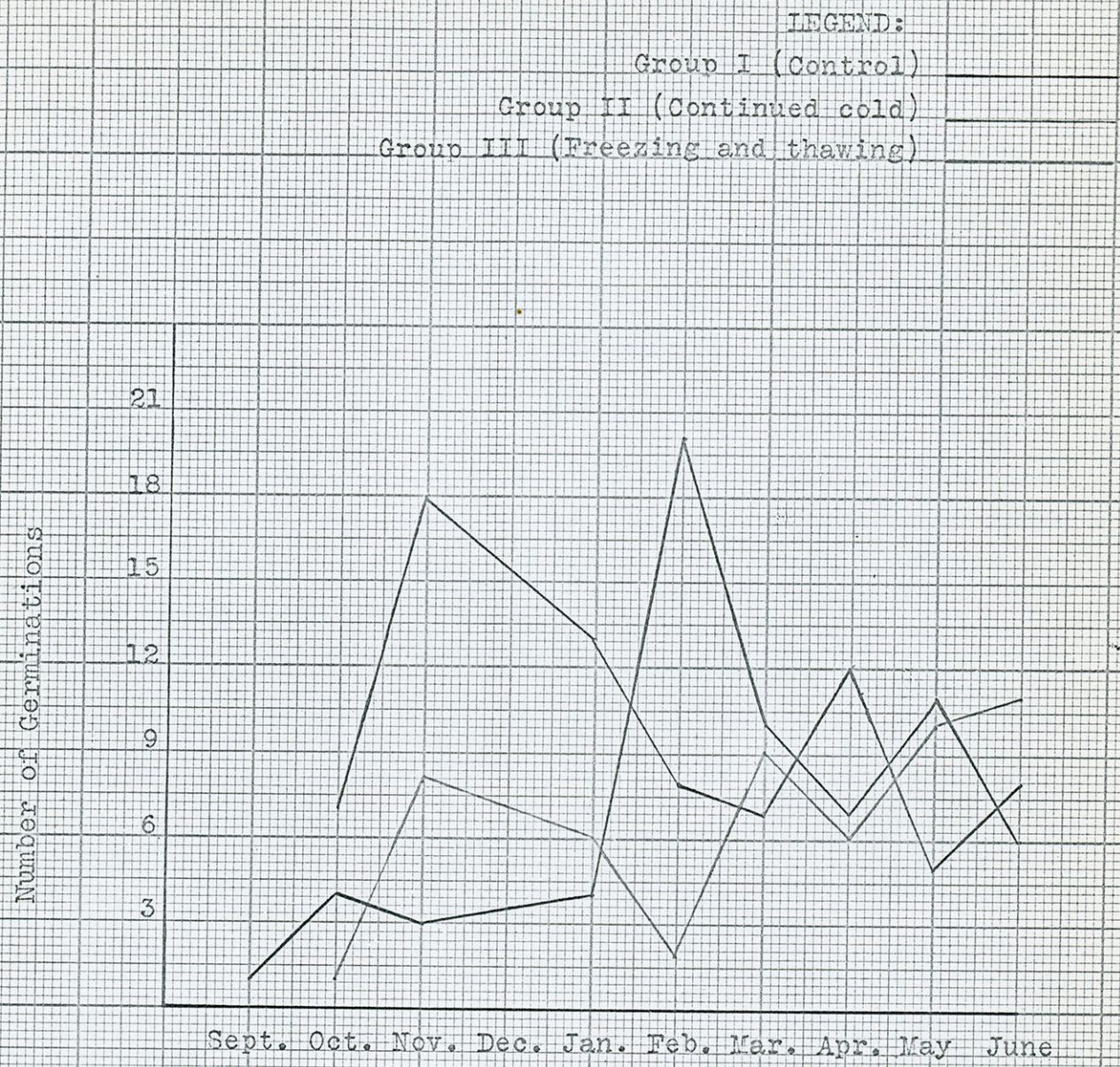
* θ - no maximum germination present.

Amaranthus rectroflexus

In Table V it is noted that Amaranthus retroflexus seemed to have at least two natural periods for germination. Figure 4 pictures two peaks of germination in each of the three groups. In Group I the peaks are shown in February and May. In Group II they appear in November and April while those in Group III are found in November and March and June.

In seventeen of the twenty-five plantings the maximum or greatest germination was on the date of the first germination.

The per cent of combined germination of all seeds in Group I was 7.3 per cent, for all seeds in Group II it was 9.7 per cent, and for all seeds in Group III it was 6.6 per cent.



Fifure 4. A Comparative Study of Germination in Nine Plantings of Amaranthus retroflexus

TABLE V

Germination Data of *Amaranthus retroflexus*

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept.21	I	100	5	5	1	1
Oct. 5	I	100	124	124	4	4
	II	100	14	103	7	7
	III	100	98	98	1	1
Nov. 10	I	100	67	67	3	3
	II	100	58	58	18	18
	III	100	57	57	8	8
Jan. 5	I	100	23	23	4	4
	II	100	11	11	13	13
	III	100	6	11	6	6
Feb. 2	I	100	8	8	20	20
	II	100	8	8	8	8
	III	100	93	93	2	2
Mar. 15	I	100	16	19	10	10
	II	100	15	15	7	7
	III	100	8	15	9	9
Apr. 13	I	100	6	13	7	7
	II	100	3	13	12	12
	III	100	10	10	6	6
May 25	I	100	5	5	11	11
	II	100	5	5	5	5
	III	100	5	5	10	10
June 8	I	100	6	6	6	6
	II	100	7	9	8	8
	III	100	6	9	11	11
Total	I	900	--	--	66	7.3
	II	800	--	--	78	9.7
	III	800	--	--	53	6.6

Abutilon Theophrasti

Germinational data for Abutilon Theophrasti are found in Table VI. Since Group I had no plantings made for the months of April, May, and June the results and observations are not complete for that group.

A study of Figure 5 makes plain the fact that germination was low in September and October. No peaks of germination appeared in any of the groups in the fall or winter months. Group II showed one peak in May and Group III one peak in June.

In fourteen of the maximum germinations occurring, the maximum germinations were first germinations. Four plantings which germinated produced no maximum germinations.

The per cent of combined germinations for all seeds in Groups I, II, and III was 1.3, 1.4, and 9.3 per cent, respectively.

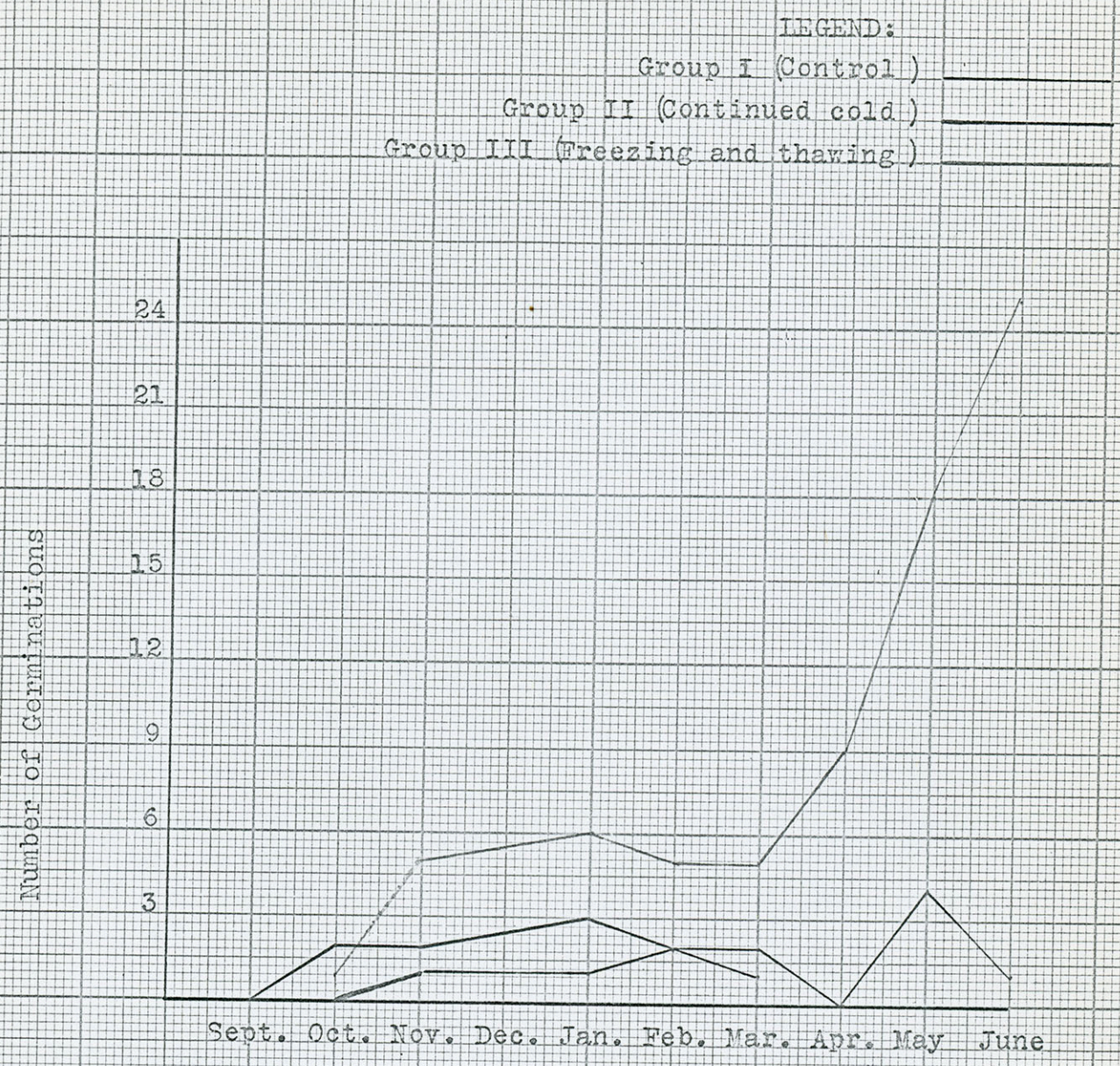


Figure 5. A Comparative Study of Germination in Nine Plantings of Abutilon Theophrasti

TABLE VI

Germination Data of Abutilon Theophrasti

Planting date	Storage group	Number seeds planted	No. of days until first germination	maximum germination	No. seeds germ.	Per cent seeds germ.
Sept. 21	I	100	--	--	0	0
Oct. 5	I	100	6	θ*	2	2
	II	100	--	--	0	0
	III	100	123	123	1	1
Nov. 10	I	100	62	62	2	2
	II	100	132	132	1	1
	III	100	62	87	5	5
Jan. 5	I	100	14	θ	3	3
	II	100	77	77	1	1
	III	100	6	6	6	6
Feb. 2	I	100	21	θ	2	2
	II	100	8	θ	2	2
	III	100	4	4	5	5
Mar. 15	I	100	9	9	1	1
	II	100	8	8	2	2
	III	100	8	8	5	5
Apr. 13	I	No seeds planted				
	II	100	--	--	0	0
	III	100	10	10	9	9
May 25	I	No seeds planted				
	II	100	5	5	4	4
	III	100	5	5	18	18
June 8	I	No seeds planted				
	II	100	15	15	1	1
	III	100	4	4	25	25
Total	I	600	--	--	8	1.3
	II	800	--	--	11	1.4
	III	800	--	--	74	9.3

* θ - no maximum germination present.

Sida spinosa

From a study of Table VII it is noted that of all seeds planted Sida spinosa produced the greatest percentage of germination with well developed peaks. Figure 6 shows that two peaks in germination developed in each of the three groups. In Group I the peaks appeared in January and May. In Group II they appeared in November, January and March and June, while in Group III they were found in November and April.

Thirteen of the eighteen maximum germinations were on the first germination date. Germinations in six of the plantings failed to produce maximum germinations.

The per cent of combined germinations for all seeds in Group I was 16.2 per cent, for all seeds in Group II it was 34.3 per cent and for all seeds in Group III it was 41 per cent.

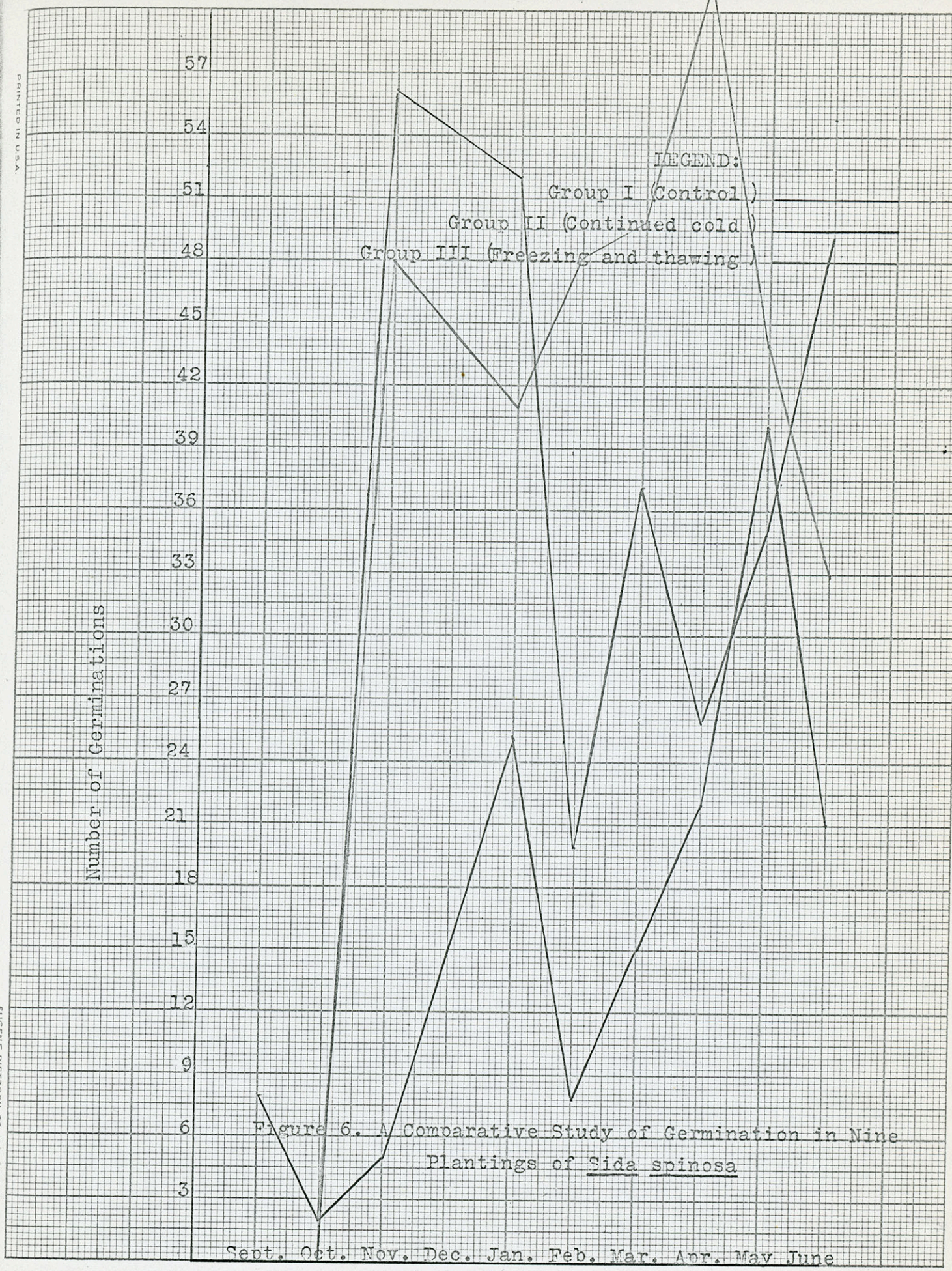


Figure 6. A Comparative Study of Germination in Nine Plantings of Sida spinosa

TABLE VII

Germination Data of *Sida spinosa*

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept. 21	I	100	28	28	8	8
Oct. 5	I	100	124	θ	2	2
	II	100	--	--	0	0
	III	100	21	θ	2	2
Nov. 10	I	100	44	θ	5	5
	II	100	14	104	56	56
	III	100	21	104	48	48
Jan. 5	I	100	11	θ	25	25
	II	100	11	48	52	52
	III	100	6	48	41	41
Feb. 2	I	100	4	4	8	8
	II	100	4	4	20	20
	III	100	4	θ	48	48
Mar. 15	I	100	9	9	15	15
	II	100	8	θ	37	37
	III	100	8	15	50	50
Apr. 13	I	100	6	6	22	22
	II	100	3	3	26	26
	III	100	10	10	62	62
May 25	I	100	5	5	40	40
	II	100	5	5	35	35
	III	100	5	5	44	44
June 8	I	100	6	6	21	21
	II	100	4	4	49	49
	III	100	4	4	33	33
Total	I	900	--	--	146	16.2
	II	800	--	--	275	34.3
	III	800	--	--	328	41.0

* θ - no maximum germination present.

Helianthus annuus yielded no germinations in all test plantings. Here was a strange situation; even though all test plantings of all four groups of seeds had no germinations, seeds that were spilled on the ground during the process of threshing in September germinated abundantly the following spring.

Pentstemon Digitalis

It was found that Pentstemon Digitalis varied greatly in its germinative ability. Figure 7 gives a very vivid graph picture of the variation. The graph shows that all three groups had favorable months for germination. For Group I the favorable months were September and January, while October, February and April seemed most favorable in Group II. Group III had but one peak and that was in January.

Twelve of the sixteen maximum germinations were first germinations. Germinations in three of the plantings took place with no maximum germination appearing.

Freezing and thawing had an unfavorable effect on Pentstemon Digitalis for the lowest number of germinations were found in Group III. Germinations in Groups I, II and III were 4.4, 4.7, and 2.7 per cent, respectively.

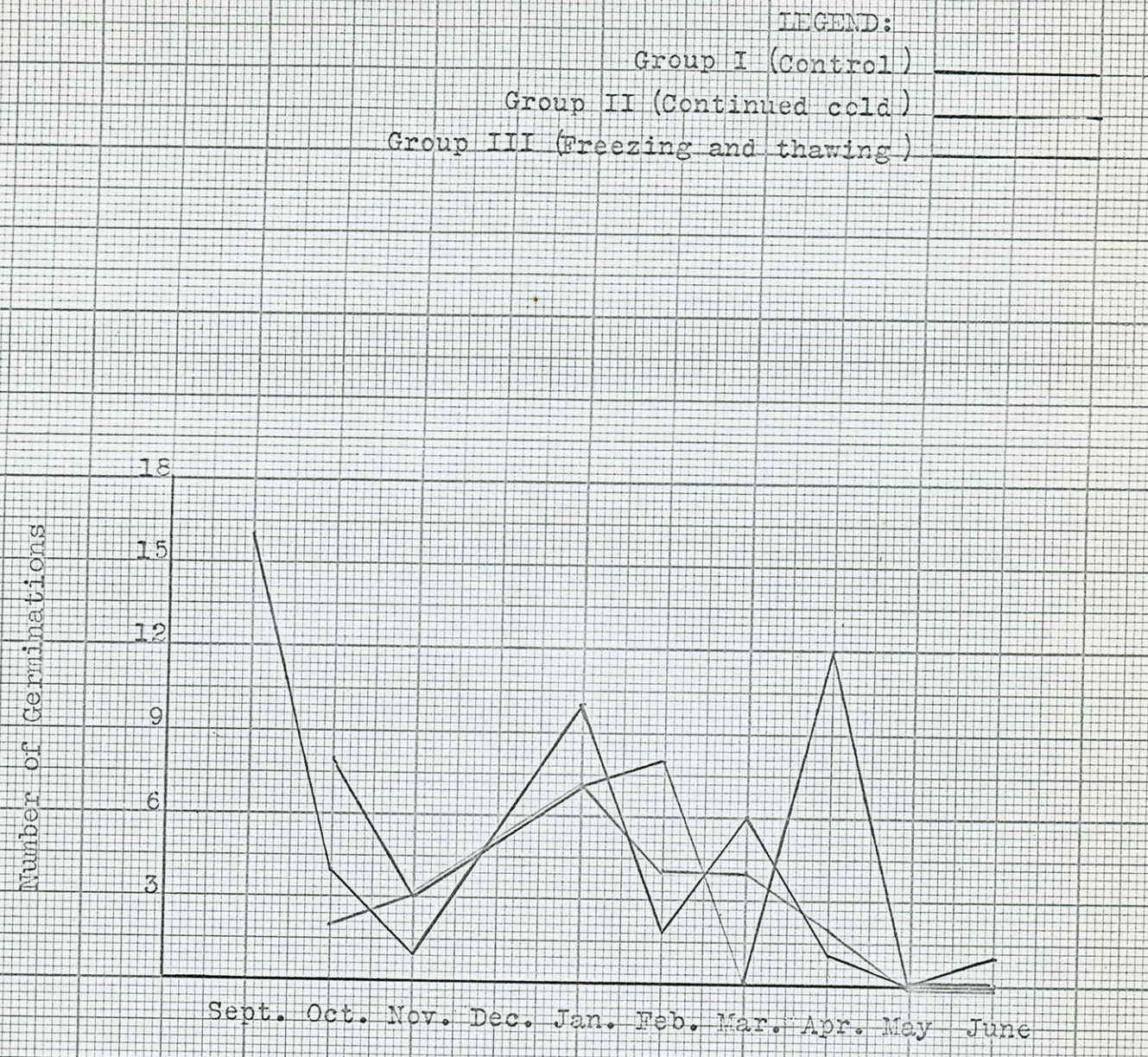


Figure 7. A Comparative Study of Germination in Nine Plantings of Pentstemon Digitalis

TABLE VIII

Germination Data of Pentstemon Digitalis

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept.21	I	100	50	θ*	16	16
Oct. 5	I	100	5	5	4	4
	II	100	14	14	8	8
	III	100	5	5	2	2
Nov. 10	I	100	55	55	1	1
	II	100	53	53	3	3
	III	100	41	92	3	3
Jan. 5	I	100	23	23	10	10
	II	100	23	23	7	7
	III	100	23	23	7	7
Feb. 2	I	100	15	15	2	2
	II	100	21	39	8	8
	III	100	26	40	4	4
Mar. 15	I	100	15	θ	6	6
	II	100	--	--	0	0
	III	100	20	θ	4	4
Apr. 13	I	100	22	22	1	1
	II	100	13	26	12	12
	III	100	34	34	2	2
May 25	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
June 8	I	100	12	12	1	1
	II	100	--	--	0	0
	III	100	--	--	0	0
Total	I	900	--	--	40	4.4
	II	800	--	--	38	4.7
	III	800	--	--	22	2.7

* θ - no maximum germination present.

Solanum rostratum

From a study of Table IX it is noted that Solanum rostratum responded with a very low percentage of germination especially in Groups I and III. With this low germination there were indications of peaks as may be observed in Figure 8. For Group I these peaks appeared in November and March, for Group II in January and March, and for Group III in October and March.

Seven, or all of the maximum germinations, were first germinations. There was one planting with no maximum germination present.

The per cent of combined germinations for all seeds in Groups I, II, and III was 0.66, 2.25, and 0.275 per cent, respectively.

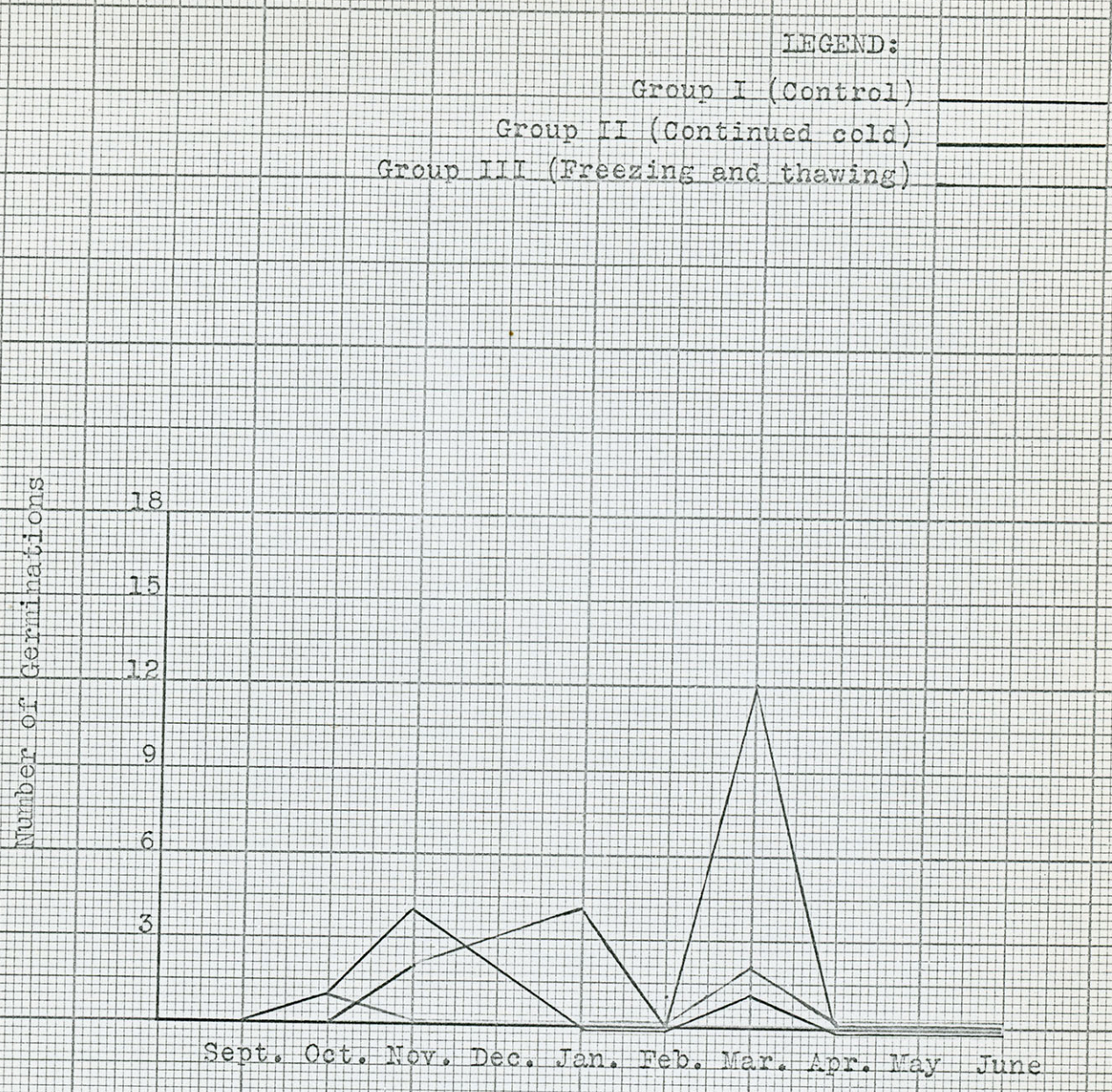


Figure 8. A Comparative Study of Germination in Nine Plantings of Solanum rostratum

TABLE IX

Germination Data of *Solanum rostratum* Dunal

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Sept.21	I	100	--	--	0	0
Oct. 5	I	100	5	5	1	1
	II	100	--	--	0	0
	III	100	21	21	1	1
Nov. 10	I	100	67	67	4	4
	II	100	66	66	2	2
	III	100	--	--	0	0
Jan. 5	I	100	--	--	0	0
	II	100	23	23	4	4
	III	100	--	--	0	0
Feb. 2	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Mar. 15	I	100	9	9	1	1
	II	100	21	21	12	12
	III	100	20	θ*	2	2
Apr. 13	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
May 25	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
June 8	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Total	I	900	--	--	6	0.66
	II	800	--	--	18	2.25
	III	800	--	--	3	0.275

* θ - no maximum germination present.

Chenopodium ambrosioides

A study of the germination data of Chenopodium ambrosioides in Table X shows that Group I had poor germination in its series of plantings. Groups II and III germinated much better than Group I as can be noted from the given per cents.

Figure 9 indicates no peaks in germination for Group I but Groups II and III had peaks in each of the three months of January, March, and June.

Ten of the eleven maximum germinations were first germinations.

The per cent of combined germinations of all seeds in Group I was 0.25 per cent, for all seeds in Group II it was 7 per cent and for all seeds in Group III it was 7.8 per cent.

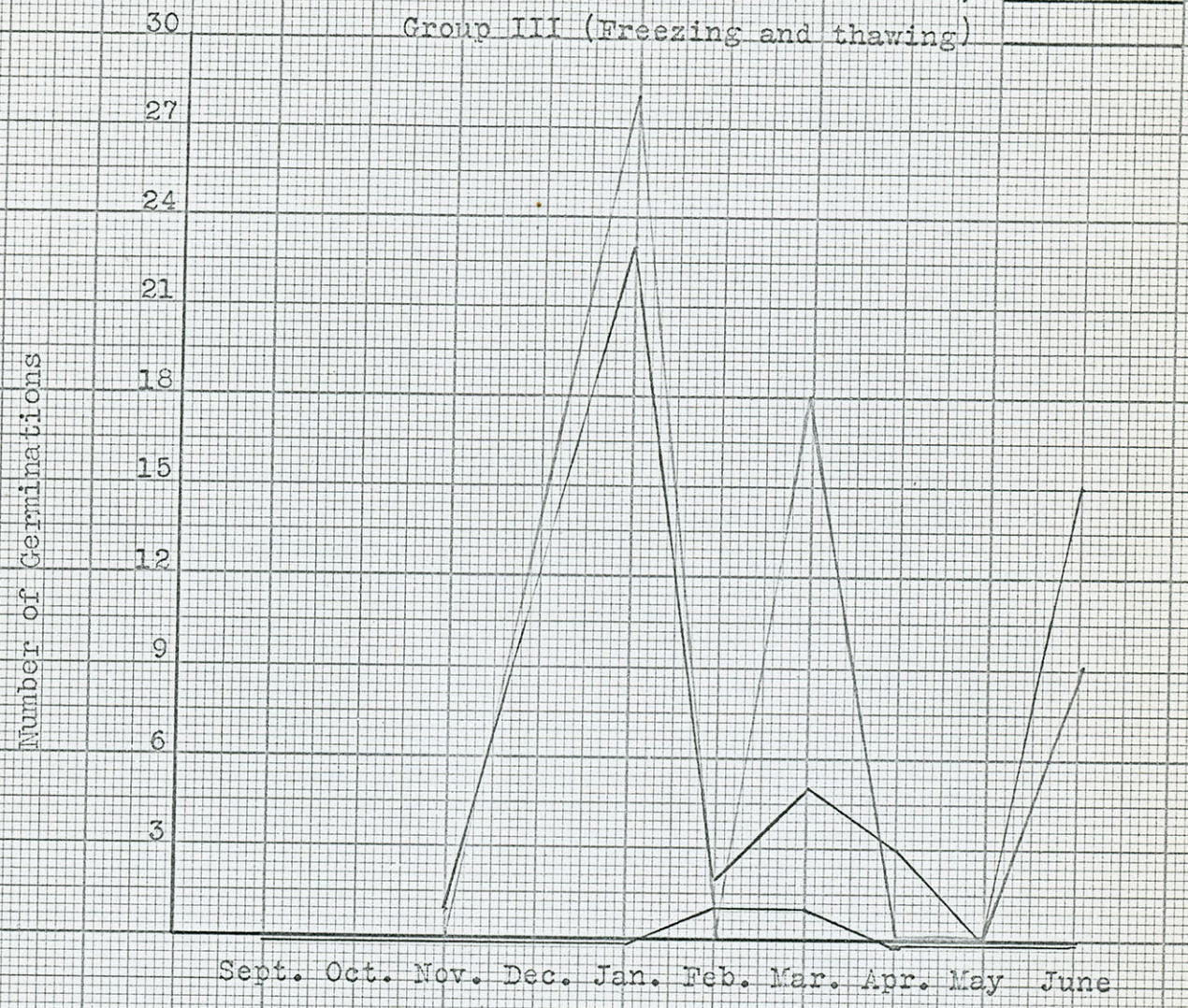


Figure 9. A Comparative Study of Germination in Nine Plantings of Chenopodium ambrosioides

TABLE X

Germination Data of Chenopodium ambrosioides

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Oct. 5	I	100	--	--	0	0
	II	No seeds planted				
	III	No seeds planted				
Nov. 10	I	100	--	--	0	0
	II	100	92	92	1	1
	III	100	--	--	0	0
Jan. 5	I	100	--	--	0	0
	II	100	11	11	23	23
	III	100	11	11	28	28
Feb. 2	I	100	117	117	1	1
	II	100	26	26	2	2
	III	100	--	--	0	0
Mar. 15	I	100	15	15	1	1
	II	100	21	21	5	5
	III	100	15	15	18	18
Apr. 13	I	100	--	--	0	0
	II	100	6	13	3	3
	III	100	--	--	0	0
May 25	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
June 8	I	100	--	--	0	0
	II	100	6	6	15	15
	III	100	7	7	9	9
Total	I	800	--	--	2	.25
	II	700	--	--	49	7.0
	III	700	--	--	55	7.8

Chenopodium album

From a study of the germination data found in Table XI it is noted that Chenopodium album produced fewer germinations than any other of the ten species germinating. There seems to be no natural periods which favor germination. There was never more than one germination in any one of the twenty-five plantings. This low percentage of germination is shown in Figure 10.

The per cent of combined germinations for all seeds in Group I was 0.375 per cent, for all seeds in Group II it was 0.375 per cent, and for all seeds in Group III it was 0.25 per cent.

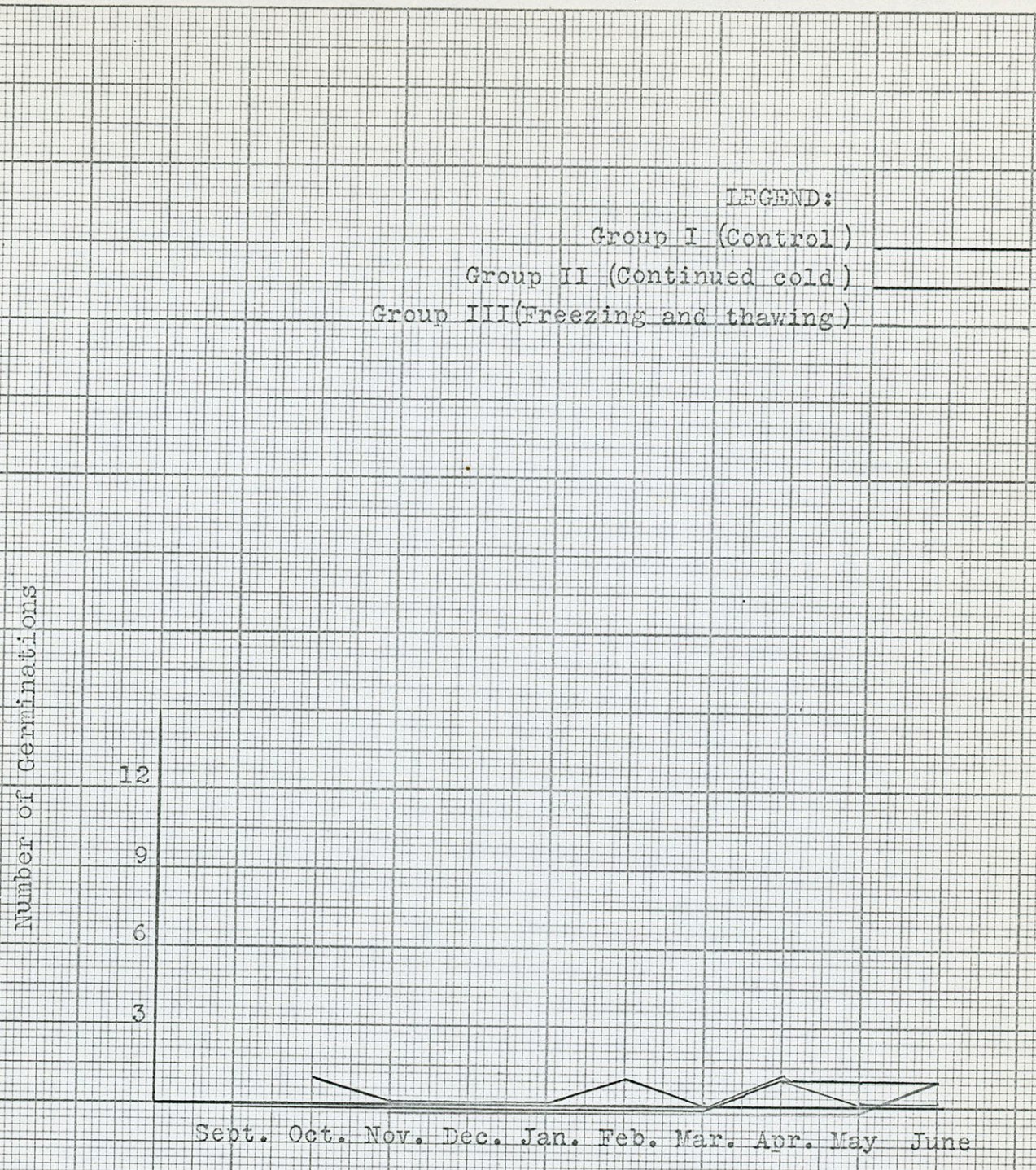


Figure 10. A Comparative Study of Germination in Nine Plantings of Chenopodium album

TABLE XI

Germination Data of *Chenopodium album* L.

Planting date	Storage group	Number seeds planted	No. of days until first germination	No. of days until maximum germination	No. seeds germ.	Per cent seeds germ.
Oct. 5	I	100	--	--	0	0
	II	100	21	21	1	1
	III	100	21	21	1	1
Nov. 10	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Jan. 5	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Feb. 2	I	100	--	--	0	0
	II	100	43	43	1	1
	III	100	--	--	0	0
Mar. 15	I	100	--	--	0	0
	II	100	--	--	0	0
	III	100	--	--	0	0
Apr. 13	I	100	13	13	1	1
	II	100	13	13	1	1
	III	100	--	--	0	0
May 25	I	100	5	5	1	1
	II	100	--	--	0	0
	III	100	--	--	0	0
June 8	I	100	6	6	1	1
	II	100	--	--	0	0
	III	100	12	12	1	1
Total	I	800	--	--	3	.375
	II	800	--	--	3	.375
	III	800	--	--	2	.25

The following table records the data on scarified and normal seeds.

TABLE XII

Germination Data of Scarified and Normal Seeds

Name of Plant	No. seeds in each planting	April	May	June
Amaranthus retroflexus				
Normal	100	7	11	6
Scarified	100	25	0	26
Chenopodium album				
Normal	100	--	1	1
Scarified	100	--	6	4
Chenopodium ambrosioides				
Normal	100	--	0	0
Scarified	100	--	0	1
Solanum rostratum				
Normal	100	--	0	0
Scarified	100	--	0	0
Helianthus annuus				
Normal	100	--	0	0
Scarified	100	--	0	0
Convolvulus arvensis				
Normal	100	--	--	1
Scarified	100	--	--	10

A study of Table XII shows that Amaranthus retroflexus had three test plantings, one each in April, May and June. In the April planting the scarified seed produced nearly three and one-half times more germinations than the control. The May planting produced no germinations with the scarified seed but 26 per cent of the control germinated. The June planting of scarified seed produced approximately four and one-half times more germinations than the control.

Chenopodium album had two test plantings. The May planting showed germinations of 1 and 6 per cent for the control and the scarified seed respectively. The June planting showed 1 and 4 per cent, respectively.

Chenopodium ambrosioides had no germinations in either of the controls and only 1 per cent of germination of scarified seed in the June planting.

Physalis lobata and Helianthus annuus produced no germinations in either controls or scarified seed.

Convolvulus arvensis was subjected to scarification for the month of June. The scarified seed produced ten times more germinations than the control. The germinations were ten and one, respectively.

SUMMARY AND CONCLUSIONS

1. The seeds from twelve common species of weeds were collected in the late summer and early fall of 1940, divided into three groups and placed under conditional storage. Group I was stored under normal conditions, Group II was subjected to continual cold, and Group III was subjected to alternate freezing and thawing. Plantings of the seeds were made monthly from September to June, exclusive of December. Seeds from six species of plants used which failed to germinate or which showed low percentages of germination in previous plantings were taken from the control group and subjected to scarification. The total number of seeds germinating in each of the three groups is shown graphically in Figure 11.
2. There were 570 germinations from the 8500 seeds planted in Group I, 771 germinations from the 7900 seeds planted in Group II, and 908 germinations from the 7900 seeds planted in Group III. From these figures it was found that Groups I, II, and III germinated 6.7, 9.7, and 11.5 per cent, respectively.
3. Not only was the combined germination of all species greater in Groups II and III but the greatest germination for each of the ten species fell five times

within Group III, two and one-half times within Group II, and two and one-half times within Group I. This showed that the greater percentage of germination was not due to an extremely high peak within a single species but to larger germinations in 75 per cent of all species.

4. In 110 of the 170 plantings which germinated, maximum germinations fell upon the first date of germination; thirty-nine times the maximum germinations came after the first germination and twenty-one times there were no maximum germination. Of these twenty-one plantings which showed no maximum germination, eleven were found in Group I, five in Group II and five in Group III.

5. From the results given it was noted that in the ten species showing germination four species in Group I, and two each in Groups II and III showed no peaks in germination during the ten months. On the other hand, six species in Group I and eight each in Groups II and III showed peaks in germination during the same time.

6. Generally speaking, germination was very low in the October plantings. This observation is in agreement with Blake (1935) in her study of prairie plants.

7. A definite increase in germination was observed as a result of seed scarification in four of the six species used.

8. Some seeds fail to germinate under test conditions but germinate readily under natural conditions.

9. It is concluded that:

   (a) Seeds of these species, in general, showed a periodicity in germination with definite maxima appearing in January, March, and May and minima in October, February, April and June (see Figure 11).

   (b) Storage conditioned by continued cold or intermittent freezing and thawing, favored increased germination of the seeds in these species.

   (c) Scarification had a favorable effect upon the germination of a limited number of species.

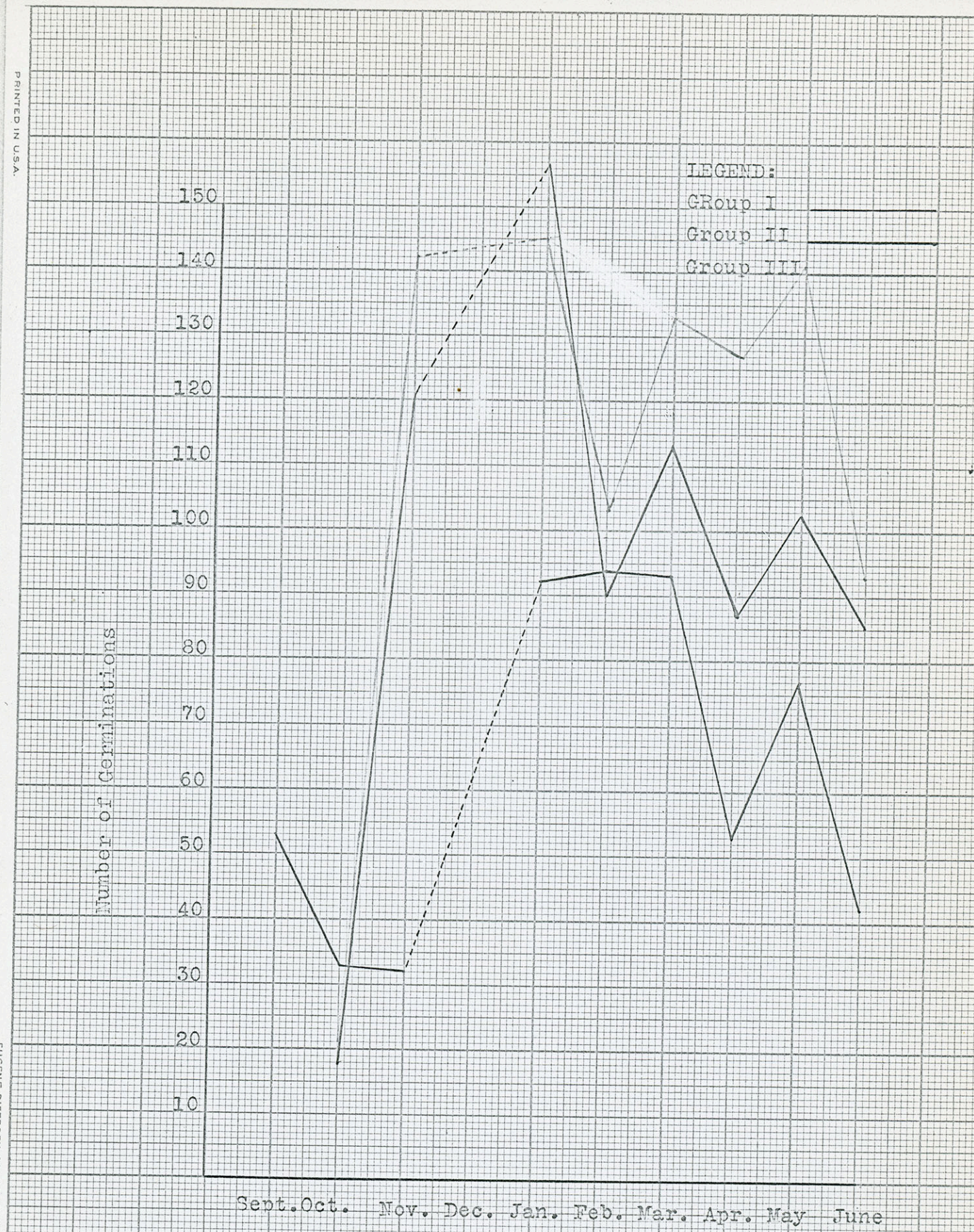


Figure 11. A Comparative Study of the Total Germination of all Seeds in Groups I, II, and III

B I B L I O G R A P H Y

BIBLIOGRAPHY

Blake, Abigail Kincaid. 1935. Viability and germination of seeds and early life history of prairie plants. Ecol. Mono. 5: 405-460.

Crocker, William. 1938. Life -Span of seeds. Bot. Rev. 4: 235-274.

Duvel, J. W. T. 1905. The storage and germination of wild rice seed. U. S. Dept. Agr. Bur. Pl. Bull. pt. 1. 16 pp. (Cited by Crocker)

Fawcett, H. S. 1908. The viability of weed seeds under different conditions of treatment, and a study of their dormant periods. Proc. Iowa Acad. Sci. 15: 25-45.

Gates, F. C. 1932. Wild Flowers in Kansas. Quar. Rept. Kan. St. Bd. Agri. Vol. 51, No. 204-B, Topeka.

_____ 1940. Flora of Kansas. Kan. State Printing Plant, Topeka.

Jones, H. A. 1920. Physiological study of maple seeds. Bot. Gaz. 69: 127-152.

Nakajima Y. 1925. Length of life of the seed of the genus Salix (Japanese) Bot. Mag. (Tokyo) 35: 17-42, 1921. (Cited from Crocker,1938)

Rydberg, P. A. 1932. Flora of the prairies and plains of central North America. N. Y. Botanical Gardens.